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TEMPERATURE DEPENDENCE OF ATOMIC REARRANGEMENT IN THE Ni_3Co ALLOY

Our previous measurements /1/ have shown that there is a dependence of the room temperature effective magnetic field and the electron density at the ^{57}Fe nucleus just following the ^{57}Co decay in the Ni_3Co alloy, on the annealing time at 700° C. This non-monotonous dependence was quantitatively interpreted in our paper /2/ in terms of short-range ordering phenomena. An analogous dependence was obtained also for directly measured high temperature isomer shift in the course of the annealing of the Ni_3Co-^{57}Fe absorber. In this work we want to show, that a similar non monotonous dependence of the Mössbauer hyperfine parameters (isomer shift in particular) in the course of the annealing of the quenched Ni_3Co-1at-% ^{57}Fe sample takes place also at lower temperatures (down to 600 °C) and indicates that an atomic rearrangement occurs at these conditions.

Mössbauer spectra were taken at double parabolic time mode velocity spectrometer NP-255 (made by the KFKI, Budapest, Hungary) with a source ^{57}Co in Pd (5 mCi). Punch take output data were processed by the least-squares method at the ZPA-600 computer. The velocity scale was calibrated by measuring the powdered sodium nitroprusside absorber. The sample had a shape of a foil (thickness 14.6 μm) and was used as absorber. Before each run of measurement, the sample was annealed at 1100° C/1 hr, cooled rapidly, mounted into the Mössbauer vacuum furnace and annealed at various temperatures within the interval 600 to 700 °C. Mössbauer spectra were taken directly during the annealing process with a gradually increasing time of measurement. Hyperfine parameters were gained by fitting a Lorentzian curve (or a magnetic sextet below the Curie temperature) to the measured spectra. For the isomer shift a typical result is shown in figure 1. This is in agreement with our previous assumption, that in the first stage of annealing the number of nickel atoms increases in the lattice sites immediately adjacent to cobalt (or iron) atoms compared with the disordered state (short range order). In course of further annealing, this effect is compensated by the influence of more distant co-ordination spheres causing the reverse changes in hyperfine parameters.

The annealing time t_o for reaching the extreme value of isomer shift and of other hyperfine parameters (e.g. the line width or - below the Curie temperature - the magnetic and quadrupole splitting) was approximately the same at the given temperature T and we have taken it as a measure of the rate of supposed ordering process. Under this assumption, the log t_o vs. 1/T dependence was plotted and revealed that the linear law is obeyed (figure 2). This is an indication of a thermally activated mechanism of the atomic rearrangements during the ordering process with the activation enthalpy of 44 ∓ 6 kcal/mol.

This value can be compared with the activation enthalpy of the volume selfdiffusion of Co in Ni 26.3 % at Co, which is 57±4 kcal/mol /3/ or 65±2 kcal/mol, respectively /4/. The cobalt diffusion in the same Ni-Co alloy at lower temperatures (up to 1000° C) is influenced by high diffusivity paths. Reported activation enthalpy of this process is ca 24 kcal/mol /4/.

The obtained value of activation enthalpy of the process studied is slightly lower than that of volume diffusion. This supports the idea that the mechanism of this process is mainly the vacancy volume diffusion, partially influenced by high diffusivity paths (from the microstructural point of view the high diffusivity paths represent a minor part of volume). In such a way it was shown, using the Mössbauer method that the supposed short-range ordering process in the Ni_3Co alloy is controlled by a thermally activated mechanism with an effective activation enthalpy given by both the mentioned diffusion processes.

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References

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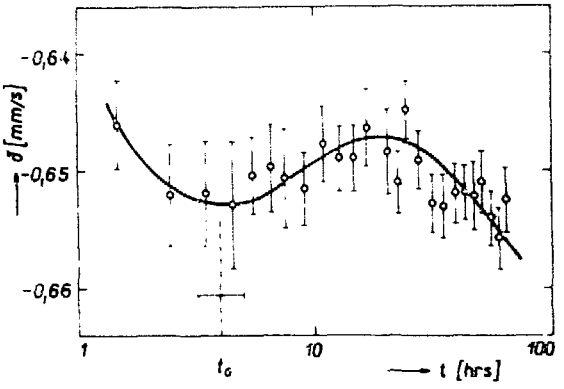

Fig.1. Time dependence of the isomer shift δ of quenched Ni_3Co specimen (1100 °C/1 hr/furnace cooling) in the course of annealing at 680 °C

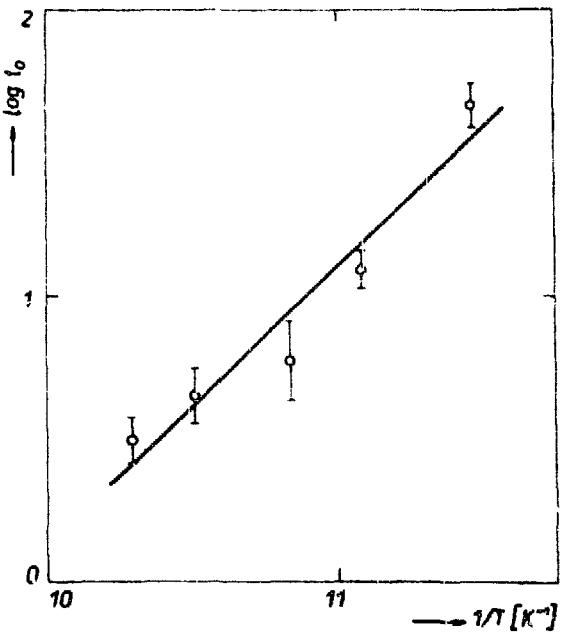

Fig.2. Temperature dependence of logarithm of time for reaching the extreme value of the isomer shift

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DETERMINATION OF THE SHORT/RANGE ORDER IN Fe-Al ALLOYS OF DIFFERENT THERMAL AND MECHANICAL TREATMENT USING THE MÖSSBAUER EFFECT

Fe-Al alloys with Al concentrations < 20 at-% in most papers are generally thought to be completely disordered. However, in these alloys one can also observe ordering phenomena and, probably depending on the latter ones, the so called K-state in annealed specimens, i.e. the increase of the electrical resistance as compared with that of the cold-rolled or quenched material. Two of the authors have dealed with this problem in earlier papers /1,2/, but they investigated a Fe 12.3 at-% Al alloy only, and took into account only two neighbouring shells of the Mössbauer atoms in calculating the short-range order parameters of the alloy. Now we have extended our investiagtions of a Fe 19.2 at-% Al alloy and taken also into account the influence of the third and fourth coordination shell on the central Fe-atom. The first time the method of determination of short-range order parameters of ferromagnetic alloys by means of Mössbauer spectroscopy was applied by Heilmann et al. /3/. The method bases on the dependence on the spectra parameters, especially of the magnetic splitting, of an individual Mössbauer atom on its individual environment in the alloy. The structure of the measured spectra, which results as a superposition of these individual spectra, contains the information on the different environments of the Mössbauer atoms and enables the determination of the short-range order.

For quantitatively describing the atomic distribution in the solid solution Fe_mAl_{1-m}, the short-range order coefficient α_1 after Cowley /4/ is used. In terms of this coefficient the